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U. S. NAVAL PROVING GROUND  
DAHLGREN, VIRGINIA

REPORT NO. 1150

DEVELOPMENT OF A COOL PROPELLANT  
FOR THE 5"/54 CALIBER GUN

8th Partial Report

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BALLISTIC TEST OF COOL PROPELLANTS  
EX-7016 - EX-7021 INCLUSIVE, EX-7038, AND  
EX-7048 - EX-7050 INCLUSIVE

FINAL Report

Copy No. 11

Task

Assignment NPG-Re2d-61-1-53

Classification CONFIDENTIAL  
SECURITY INFORMATION

Ballistic Test of Cool Propellants EX-7016 - EX-7021 inclusive,  
EX-7038, and EX-7048 - EX-7050 inclusive

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PART A

SYNOPSIS

1. This is the eighth partial report on Task Assignment NPG-Re2d-61-1-53, the "Development of a Cool Propellant for the 5"/54 Caliber Gun", and the final report on "Ballistic Test of Cool Propellants EX-7016 - EX-7021 inclusive, EX-7038, and EX-7048 - EX-7050 inclusive".

2. From the results of the subject tests, it is concluded that:

a. None of the subject propellants tested in the 5"/54 caliber gun (Mk 18 or Mk 16) were satisfactory at 3000-3100 f/s velocity in the 22-24 tsi pressure range within the limitation of 3.5 PPD (Production Packing Depth).

b. Difficulty in establishing and maintaining optimum powder packing conditions was experienced due to the soft and fish-scale surface structures of EX-7016 through EX-7021. For the assessed charge of 20.75 lb. of EX-7020, an increase of 1.5 in PPD was obtained by graphiting the powder.

c. EX-7038 was unsatisfactory as a replacement for EX-6883.

d. Mono-perforated powders are readily ignitable and show possibilities for use at higher velocities and pressures in the 5"/54 caliber gun.

e. No appreciable differences in ballistics were obtained between the EX-23-1 and Mk 41-0 (60 lb.) projectiles.

Preliminary firings indicate that propellants with higher relative ignitability and larger percent nitrate nitrogen are more sensitive to basic ignition changes.

f. The pressure-time curves obtained with the subject propellants had steps occurring in the pressure-rise region and in general were rougher than those obtained with EX-6822 or EX-6883.

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EX-7038, and EX-7048 - EX-7050 inclusive

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Ballistic Test of Cool Propellants EX-7016 - EX-7021 inclusive,  
EX-7038, and EX-7048 - EX-7050 inclusive

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## PART B

### INTRODUCTION

#### 1. AUTHORITY:

The tests reported herein were authorized by references (b), (c), and (d) and conducted under Task Assignment NPG-Re2d-61-1-53 as established by reference (a).

#### 2. REFERENCES:

- a. BUORD Conf ltr Re2d-CNB:aph Ser 42692 of 29 July 1952
- b. BUORD Conf ltr Re2d-CNB:aph Ser 44705 of 12 Sept 1952
- c. BUORD Conf ltr NP9 Re2d-ERD:jd Ser 47824 of 18 Nov 1952
- d. BUORD Conf ltr NP9 Re2d-ERD:dad Ser 48931 of 10 Dec 1952
- e. BUORD Conf ltr Re2d-ERD:aph Ser 47419 of 7 Nov 1952 to E. I. duPont Company
- f. NPG Conf Report No. 984 of 18 Aug 1952
- g. Description Sheets of Manufacture and Closed Bomb Data
- h. USNPF Conf Report No. 40 (NAVORD Report No. 3011) of 15 May 1952
- i. NPG Conf Report No. 873 of 17 Dec 1951

#### 3. BACKGROUND:

Reference (a) established the general task for the development of cool powders for the 5"/54 caliber gun. Reference (b) requested that EX-7016 through EX-7021 be fired for ballistic assessment in the 5"/54 caliber gun with the 60 lb. projectile in the 22-24 ton pressure range at a velocity of 3000 to 3100 f/s. Reference (b) described these propellants as cool picrite powders with a nominal flame temperature around 2350°K, prepared by duPont to determine the effect of variation in nitrate nitrogen content on ignition and gun ballistics. Reference (c) requested that EX-7038 be fired for charge determination in the 5"/54 caliber gun and described it as a 2350°K (nominal) picrite propellant for possible use as a replacement for EX-6883 in the continuation of the rapid fire-wear program as reported in reference (f). Reference (d) requested EX-7048, 7049 and 7050 (mono-perforated) be fired for ballistic assessment in the 5"/54 caliber gun. Reference (d) described these propellants as cool picrite powders prepared in accordance with reference (e). Reference (h) described the development of a method for the determination of the ignitability of propellants.

Ballistic Test of Cool Propellants EX-7016 - EX-7021 inclusive,  
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#### 4. OBJECT OF TEST:

a. To determine whether EX-7016 to EX-7019 are ballistically suitable for the 5"/54 caliber gun using the 60 lb. projectile at a pressure of 22-24 tsi and velocity between 3000 and 3100 f/s.

b. To determine the effect of increased nitrate nitrogen content on ignition and ballistics.

c. To determine whether EX-7038 is a satisfactory replacement for EX-6883.

d. To determine whether mono-perforated propellants (EX-7048-7049-7050) are suitable ballistically for the 5"/54 caliber gun.

e. To determine if the subject propellants are ballistically satisfactory within a PPD (Production Packing Depth) of 3"5. (This value allows for manufacturing tolerances between different powder lots and is essential in the assembly of 5"/54 cone-crimped ammunition).

#### 5. PERIOD OF TEST:

a. Dates of Project Letters:

29 July 1952  
12 Sep 1952  
7 Nov 1952  
18 Nov 1952  
10 Dec 1952

b. Dates Material Received:

EX-7016 to 7019 inclusive

7 Aug 1952

EX-7038

14 Oct 1952

EX-7048-7049-7050

10 Dec 1952

c. Date Commenced Test:

13 Dec 1952

d. Date Test Completed:

2 Feb 1953

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PART C

DETAILS OF TEST

6. DESCRIPTION OF ITEMS UNDER TEST:

Reference (g) gave in detail the powder description and closed bomb data. A summary of the data follows:

<u>Actual Composition</u>	<u>EX-7016</u>	<u>EX-7017</u>	<u>EX-7018</u>
Nitrocellulose (13.20%N)	20.42%	20.33%	20.58%
Nitroglycerin #1	19.48	19.18	19.37
Picrite	50.51	51.12	50.49
Centralite	1.71	1.54	1.55
Dibutylphthalate	7.88	7.83	8.02
Lead Carbonate (added)	0.93	0.84	0.94

<u>Actual Composition</u>	<u>EX-7019</u>	<u>EX-7020</u>	<u>EX-7021</u>	<u>EX-6883</u>
Nitrocellulose (13.20%N)	31.12	31.00	30.48	19.98
Nitroglycerin #1	18.85	19.28	19.43	14.61
Picrite	39.41	39.64	39.58	58.40
Centralite	2.00	1.56	2.01	1.47
Dibutylphthalate	8.62	8.52	8.50	5.54
Lead Carbonate (added)	0.98	0.92	1.00	1.01

<u>Actual Composition</u>	<u>EX-7038</u>	<u>EX-7048</u>	<u>EX-7049</u>	<u>EX-7050</u>
Nitrocellulose (13.20%N)	19.16	19.90	19.20	19.08
Nitroglycerin #3	15.29(*)	15.36	14.69	14.42
Picrite	59.16	58.12	58.04	58.61
Centralite	1.81	2.02	1.97	1.88
Dibutylphthalate	4.58	4.60	4.94	4.76
Lead Carbonate (added)	0.96	0.95	0.96	0.99

\* Nitroglycerin #1 with EX-7038

Reference (g) also gave the following information:

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Sample	Calc. Flame Temp. (°K)	Grain Dimensions			No. of Perfs.	RQ (%)	RF (%)	Nitrate Nitrogen (%)	Relative Ignitability (%)
		Length (in.)	Diam. (in.)	Av. Web (in.)					
EX-7016	2334	0.5460	0.2377	0.0422	7	95.7(a) 105.9(b) 82.8(a) 89.9(b) 72.1(a) 78.2(b) 103.5(a) 112.5(b) 86.0(a) 93.5(b) 72.9(a) 79.2(b) 88.5(a) 97.8(b) 90.8(c) 96.8(b) 91.4(c)	97.8(a) 110.3(b) 98.9(a) 111.6(b) 98.0(a) 111.0(b) 99.3(a) 112.7(b) 98.2(a) 111.5(b) 97.3(a) 110.4(b) 98.2(a) 112.8(b) 95.9(c) 113.2(b) 97.0(c)	6.42	180
EX-7017	2348	0.7150	0.2952	0.0512	7	82.8(a) 89.9(b) 72.1(a) 78.2(b) 103.5(a) 112.5(b) 86.0(a) 93.5(b) 72.9(a) 79.2(b) 88.5(a) 97.8(b) 90.8(c) 96.8(b) 91.4(c)	98.9(a) 111.6(b) 98.0(a) 111.0(b) 99.3(a) 112.7(b) 98.2(a) 111.5(b) 97.3(a) 110.4(b) 98.2(a) 112.8(b) 95.9(c) 113.2(b) 97.0(c)		190
EX-7018	2336	0.7400	0.3304	0.0596	7	72.1(a) 78.2(b) 103.5(a) 112.5(b) 86.0(a) 93.5(b) 72.9(a) 79.2(b) 88.5(a) 97.8(b) 90.8(c) 96.8(b) 91.4(c)	98.0(a) 111.0(b) 99.3(a) 112.7(b) 98.2(a) 111.5(b) 97.3(a) 110.4(b) 98.2(a) 112.8(b) 95.9(c) 113.2(b) 97.0(c)		181
EX-7019	2381	0.5490	0.2323	0.0415	7	103.5(a) 112.5(b) 86.0(a) 93.5(b) 72.9(a) 79.2(b) 88.5(a) 97.8(b) 90.8(c) 96.8(b) 91.4(c)	99.3(a) 112.7(b) 98.2(a) 111.5(b) 97.3(a) 110.4(b) 98.2(a) 112.8(b) 95.9(c) 113.2(b) 97.0(c)	7.56	277
EX-7020	2387	0.6613	0.3029	0.0510	7	86.0(a) 93.5(b) 72.9(a) 79.2(b) 88.5(a) 97.8(b) 90.8(c) 96.8(b) 91.4(c)	98.2(a) 111.5(b) 97.3(a) 110.4(b) 98.2(a) 112.8(b) 95.9(c) 113.2(b) 97.0(c)		287
EX-7021	2332	0.7490	0.3238	0.0589	7	72.9(a) 79.2(b) 88.5(a) 97.8(b) 90.8(c) 96.8(b) 91.4(c)	97.3(a) 110.4(b) 98.2(a) 112.8(b) 95.9(c) 113.2(b) 97.0(c)		273
EX-7038	2435	0.7220	0.2873	0.0504	7	97.8(b) 90.8(c) 96.8(b) 91.4(c)	112.8(b) 95.9(c) 113.2(b) 97.0(c)		
EX-7048	2436	0.3709	0.1428	0.0626	1	102.9(d) 79.5(b) 75.0(c)	100.7(d) 111.1(b) 95.3(c)		
EX-7049	2387	0.4270	0.1578	0.0705	1	84.4(d) 75.6(b) 71.5(c)	98.8(d) 110.8(b) 95.0(c)		
EX-7050	2393	0.4605	0.1778	0.0773	1	80.4(d)	98.6(d)		
EX-6883	2378	0.5750	0.2498	0.0457	7	108.2(b)	114.1(b)	5.03	150

(a) Based on EX-6833 as 100% at 90°F.

(b) Based on EX-6586 as 100% at 90°F.

(c) Based on EX-6882 as 100% at 90°F.

(d) Based on EX-7038 as 100% at 90°F.

(e) Based on Cordite N powder as 100%. (reference (h)).

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## 7. PROCEDURE:

a. The subject propellants were fired in either the Mk 16-0 or Mk 18-0 5"/54 caliber guns. Comparative firings were conducted with related powders listed in references (f) and (i). All tests were conducted with the 60 lb. projectile for 3000-3100 f/s velocity and 22-24 tsi pressure.

Muzzle velocities, maximum pressures (copper crusher), ejection times, and visual observations of flash and smoke were obtained. Pressure-time records were obtained on representative powders.

b. Tests were conducted to determine powder packing depth differences with graphited and non-graphited powder.

## 8. RESULTS AND DISCUSSION:

The results of the subject tests are given in detail in the Appendices and are summarized below:

### a. Uniformity:

Date	Gun No.	Powder	PPD (in.)	Charge (lbs.)	Velocity (f/s)	Pressure (t.s.i.)	Ejec. Time (sec.)	No. of Rds.
12-18-52	16076	EX-6883	4.6	20.15	2971±2	20.0±0.1	0.021±0.001	5
"	"	EX-7016	6.0	18.50	2850±0	21.5±0.3	0.018±0.001	2
"	"	EX-7017	5.1	18.50	2689±4	14.3±0.2	0.019±0.000	2
"	"	"	1.4	21.10	2954±1	18.4±0.2	0.019±0.001	3
"	"	EX-7018	3.1	20.00	2637±8	12.9±0.3	0.022±0.001	2
"	"	EX-7019	5.9	18.50	2930±3	26.6±0.4	0.017±0.001	2
"	"	EX-7020	4.9	18.50	2757±4	15.8±0.2	0.020±0.002	2
"	"	"	1.4	20.90	3004±8	20.2±0.1	0.017±0.001	2
"	"	EX-7021	4.6	19.00	2579±9	12.4±0.1	0.019±0.000	2
"	"	"	1.4	21.20	2809±4	15.2±0.1	0.021±0.001	2
"	"	EX-7038	7.2	18.00	2659±2	14.2±0.1	0.021±0.001	3
"	"	"	1.4	22.20	3070±4	20.7±0.3	0.018±0.001	3
12-19-52	14763	EX-6883	4.6	20.15	2990±7	20.9±0.5	0.019±0.000	5
"	"	EX-7020	4.9	18.50	2771±5	16.4±0.2	0.018±0.001	3
"	"	"	1.6	20.75	3001±3	21.0±0.2	0.017±0.001	5
"	"	EX-7038	7.2	18.00	2674±1	14.4±0.1	0.021±0.001	3
"	"	"	1.4	22.20	3059±5	20.9±0.3	0.018±0.001	5
"	"	Blend (a)	2.0	20.50	3007±7	21.8±0.3	0.016±0.000	5
"	"	"	5.7	18.00	2759±2	16.8±0.1	0.018±0.001	3
"	"	EX-7020(b)	3.1	20.75	2979±5	21.2±0.1	0.017±0.001	3

Ballistic Test of Cool Propellants EX-7016 - EX-7021 inclusive,  
EX-7038, and EX-7048 - EX-7050 inclusive

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Date	Gun No.	Powder	PPD (in.)	Charge (lbs.)	Velocity (f/s)	Pressure (t.s.i.)	Ejec. Time (sec.)	No. of Rds.
12-19-52	14758	EX-6883	4.6	20.15	2940±0	18.6±0.2	0.020±0.001	3
"	"	EX-7020	1.6	20.75	2958±2	19.6±0.2	0.018±0.001	3
"	"	EX-7038	2.3	21.50	2960±7	18.6±0.2	0.017±0.000	3
"	"	Blend (a)	2.0	20.50	2975±4	21.6±0.3	0.017±0.001	3
"	"	EX-7050	7.8	18.65	2644±1	21.4±0.3	0.017±0.001	3
"	"	EX-7020(b)	3.1	20.75	2959±3	21.3±0.7	0.017±0.000	3
1-2-53	16077	EX-7038	6.7	18.50	2725±2	15.1±0.0	0.019±0.001	2
"	"	"	3.0	21.00	2966±4	18.5±0.3	0.018±0.001	4
"	"	" (c)	3.0	21.00	2960±10	17.8±0.4	0.020±0.002	5
"	"	EX-6822	7.3	18.50	2822±4	17.5±0.4	0.022±0.002	3
"	"	"	3.5	21.30	3076±5	22.0±0.2	0.019±0.001	5
"	"	" (c)	3.5	21.30	3076±7	21.8±0.3	0.019±0.002	5
"	"	EX-6883	6.9	18.50	2826±6	17.2±0.2	0.020±0.000	3
"	"	"	3.0	21.30	3099±3	21.7±0.5	0.019±0.001	5
"	"	" (c)	3.0	21.30	3102±2	21.9±0.3	0.019±0.001	5
1-22-53	14763	EX-7019(d)	8.1	17.00	2782±3	24.1±0.2	0.019±0.001	2
"	"	" (e)	8.1	17.00	2782±2	22.8±0.5	0.019±0.001	2
"	"	" (f)	8.1	17.00	2766±1	20.5±0.1	0.019±0.001	2
"	"	EX-7017(d)	1.4	21.10	2948±3	19.0±0.1	0.019±0.001	2
"	"	" (e)	1.4	21.10	2928±1	17.8±0.0	0.019±0.001	2
"	"	" (f)	1.4	21.10	2915±1	17.1±0.1	0.019±0.000	2
"	"	EX-6883(d)	4.4	20.15	2957±4	20.0±0.3	0.021±0.001	5
"	"	" (e)	4.4	20.15	2949±2	19.9±0.2	0.023±0.001	2
"	"	" (f)	4.4	20.15	2958±19	20.6±1.2		2
1-27-53	14763	EX-6822	3.0	21.56	3070±15	21.5±0.8(g)	0.020±0.002	2
"	"	EX-7019	7.7	17.00	2766±4	22.3±0.2(h) 22.2±0.2(i) 21.0±0.5(g) 20.8±0.4(h) 20.6±0.1(i)	0.019±0.002	3
1-28-53	14763	EX-6883	2.6	21.28	3063±8	21.6±0.7(g) 21.7±0.4(h) 22.5±0.5(i)	0.020±0.002(j)	5
2-2-53	16078	EX-6883	3.0(k)	21.31	3084±5	22.9±0.4	0.019±0.002	5
"	"	EX-6822	3.2(k)	21.56	3093±5	23.5±0.5	0.018±0.002	5

(a) 78/22 blend of EX-7020 and EX-7019

(b) Graphited

(c) Ex-23-1 projectile

(d) 800 grams of black powder in primer

(e) 600 " " " " " "

(f) 400 " " " " " "

(g) T-1070 - Static calibration pressure for 1/6 sq. in. area gauges.

(h) MI-2 - Dynamic calibration pressure for 1/6 sq. in area gauges

(i) MI-3 - Dynamic calibration pressure for 1/30 sq. in area gauges

(j) Based on 3 rounds

(k) Cone crimp assembly



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## b. Charge Determination:

(1) 5"/54 caliber guns (as indicated)

Firing conditions were the same as the Uniformity Firings.

Date	Powder	PPD (in.) (d)	Gun No.	Mk-Mod	Velocity (f/s)	Charge (lbs.)	Pressure (t.s.i.)	Remarks
12-13-52	EX-7016	4.2	16076	18 0	3000	20.11	26.3	Too fast
"	"	2.6	"	" "	3100	21.18	29.5(a)	Too fast
"	EX-7017	1.2	"	" "	3000	21.55	19.4	Too slow
"	"	-0.3(e)	"	" "	3100	22.53	21.6	Too slow
"	EX-7018	-2.0(e)	"	" "	3000	23.89	18.4	Too slow
"	"	-3.6(e)	"	" "	3100	24.96	19.9	Too slow
"	EX-7019	5.5	"	" "	3000	19.16	29.2(a)	Too fast
"	"	4.1	"	" "	3100	20.10	32.3(a)	Too fast
"	EX-7020	2.0	"	" "	3000	20.86	20.1	Too slow
"	"	0.5	"	" "	3100	21.83	21.9	Too slow
"	EX-7021	-0.6(e)	"	" "	3000	23.03	17.5	Too slow
"	"	-2.3(e)	"	" "	3100	23.98	18.7	Too slow
"	Blend (b)	3.5	"	" "	3000	20.47	21.2	Too slow
"	"	2.2	"	" "	3100	21.40	23.6	(f)
"	EX-7038	2.9	"	" "	3000	21.49	19.6	Too slow
"	"	1.4	"	" "	3100	22.51	21.2	Too slow
"	EX-7048	6.7	"	" "	3000	19.35	(c)	Too fast
"	"	5.3	"	" "	3100	20.26	(c)	Too fast
"	EX-7049	4.9	"	" "	3000	21.06	(c)	Too fast
"	"	3.7	"	" "	3100	21.98	(c)	Too fast
"	EX-7050	3.8	"	" "	3000	22.15	(c)	Too fast
"	"	2.5	"	" "	3100	23.12	(c)	Too fast
12-19-52	EX-7020	2.1	14763	16 0	3000	20.74	21.0	Too slow
"	"	0.7	"	" "	3100	21.72	23.0	(f)
"	EX-7038	2.8	"	" "	3000	21.56	19.9	Too slow
"	"	1.3	"	" "	3100	22.65	21.6	Too slow
"	Blend (b)	3.6	"	" "	3000	20.43	21.6	Too slow
"	"	2.3	"	" "	3100	21.44	25.7	Too fast
1-2-53	EX-7038	3.1	16077	18 0	3000	21.35	19.0	Too slow
"	"	1.7	"	" "	3100	22.39	20.4	Too slow
"	EX-6822	5.1	"	" "	3000	20.46	20.5	(h)
"	"	3.7	"	" "	3100	21.56	22.4	(h)
"	EX-6883	4.9	"	" "	3000	20.28	20.1	(g)
"	"	3.5	"	" "	3100	21.31	21.7	(g)

(a) Extrapolated value

(b) Blend of 78% EX-7020 and 22% EX-7019

(c) Over 30 t.s.i. by extrapolation

(d) PPD without gages

(e) Charge too large for cartridge case

(f) Satisfactory ballistically at 3100 f/s but unsatisfactory within PPD limits

(g) Evaluated separately in ref. (f)

(h) Evaluated separately in ref. (i)

Ballistic Test of Cool Propellants EX-7016 - EX-7021 inclusive,  
EX-7038, and EX-7048 - EX-7050 inclusive

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(2) None of the subject propellants tested in the 5"/54 caliber gun (Mk 18 or Mk 16) at 3000-3100 f/s velocity and 22-24 tsi pressure were satisfactory within 3% PPD limitation.

(3) Soft surfaces and to a greater or lesser degree inherent "fish-scale" surface structures were observed on propellants EX-7016 through EX-7021. Because of the above conditions, optimum powder packing conditions were somewhat difficult to establish and maintain. One of the powders (EX-7020) was coated with a layer of graphite. The PPD for a charge of 20.75 lb. of this powder ungraphited was 1% while the same charge with a coating of graphite was 3%, thereby allowing for 1% more free space remaining in the cartridge case.

(4) EX-7038 was too slow for the 5"/54 caliber gun and was found unsatisfactory as a replacement for EX-6883.

(5) EX-7048 through EX-7050, the first mono-perforated propellants fired in the 5"/54 caliber gun, were all too fast at either 3000 or 3100 f/s velocity.

It is evident that mono-perforated propellants are readily ignitable and have possibilities for use at higher velocities and pressures in the 5"/54 caliber gun.

(6) Comparative firings between the Ex-23-1 and Mk 41-0 (60 lb. projectiles) showed no appreciable difference in ballistics.

(7) One powder from each group was fired with different amounts of ignition in the primer. The data are as follows:

Powder Index	Charge (lbs.)	Relative Ignitability	Per Cent Nitrate Nitrogen	Ignition (grains)	Velocity (f/s)	Pressure (t.s.i.)	No. of Rds.
EX-7019	17.00	277	7.56	800	2782±3	24.1±0.2	2
"	"	"	"	600	2782±2	22.8±0.5	2
"	"	"	"	400	2766±1	20.5±0.1	2
EX-7017	21.10	190	6.42	800	2948±3	19.0±0.1	2
"	"	"	"	600	2928±1	17.8±0.0	2
"	"	"	"	400	2915±1	17.1±0.1	2
EX-6883	20.15	150	5.03	800	2957±4	20.0±0.3	2
"	"	"	"	600	2949±2	19.9±0.2	2
"	"	"	"	400(a)	2958±19	20.6±1.2	2

(a) 5 second hangfires



Ballistic Test of Cool Propellants EX-7016 - EX-7021 inclusive,  
EX-7038, and EX-7048 - EX-7050 inclusive  
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From the above results it can be seen that a propellant with a higher relative ignitability and higher percent nitrate nitrogen content is more sensitive to ignition changes.

Tests are currently being conducted on these propellants to determine ignition changes on pressure-time behavior and will be reported separately under "Case Gun Ignition" Task Assignment NPG-Re2a-184-1-53.

c. Pressure-Time Records:

(1) The pressure-time records obtained in the subject tests are presented in Appendix (B).

(2) EX-6822 and EX-6883 gave smooth pressure-time curves.

(3) The pressure-time curves obtained with EX-7038 had only slight steps occurring in the pressure-rise portion of the curves.

(4) EX-7020 (ungraphited) gave fairly pronounced steps in the pressure-rise region and were generally better than those obtained with EX-7020 after graphiting.

(5) Very large steps and rough peaks were obtained with EX-7019 and EX-7050.

(6) In general, none of the subject powders tested in the 5"/54 caliber gun gave as smooth pressure-time curves as either EX-6822 or EX-6883.

Ballistic Test of Cool Propellants EX-7016 - EX-7021 inclusive,  
EX-7038, and EX-7048 - EX-7050 inclusive  
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## PART D

### CONCLUSIONS

9. From the results of the subject tests, it is concluded that:

a. None of the subject propellants tested in the 5"/54 caliber gun (Mk 18 or Mk 16) were satisfactory at 3000-3100 f/s velocity in the 22-24 t.s.i. pressure range within the limitation of 3.5 PPD (Production Packing Depth).

b. Difficulty in establishing and maintaining optimum powder packing conditions was experienced due to the soft and fish-scale surface structures of EX-7016 through EX-7021. For the assessed charge of 20.75 lb. of EX-7020, an increase of 1.5 in PPD was obtained by graphiting the powder.

c. EX-7038 was unsatisfactory as a replacement for EX-6883.

d. Mono-perforated powders are readily ignitable and show possibilities for use at higher velocities and pressures in the 5"/54 caliber gun.

e. No appreciable differences in ballistics were obtained between the Ex-23-1 and Mk 41-0 (60 lb.) projectiles.

Preliminary firings indicate that propellants with higher relative ignitability and larger percent nitrate nitrogen are more sensitive to basic ignition changes.

f. The pressure-time curves obtained with the subject propellants had steps occurring in the pressure-rise region and in general were rougher than those obtained with EX-6822 or EX-6883.

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Ballistic Test of Cool Propellants EX-7016 - EX-7021 inclusive,  
EX-7038, and EX-7048 - EX-7050 inclusive  
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The tests upon which this report is based were conducted by:

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By direction

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U. S. NAVAL PROVING GROUND  
DAHLGREN, VIRGINIA

8th Partial Report  
on  
Development of a Cool Propellant  
for the 5"/54 Caliber Gun

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Final Report  
on  
Ballistic Test of Cool Propellants  
EX-7016 - EX-7021 inclusive, EX-7038, and  
EX-7048 - EX-7050 inclusive

Project No.: NPG-Re2d-61-1-53  
Copy No.: 11  
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Ballistic Test of Cool Propellants EX-7016 - EX-7021 inclusive,  
EX-7038, and EX-7048 - EX-7050 inclusive

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TABULATION OF FIRING DATA

Gun: 5"/54 Caliber, Mk 18-0 No. 16076  
ESR = 42.4 D<sub>0</sub> = 5.010  
Mk 16-0 No. 14763  
ESR = 180.5 D<sub>0</sub> = 5.056  
Mk 16-0 No. 14758  
ESR = 296.8 D<sub>0</sub> = 5.074  
Mk 18-0 No. 16077  
ESR = 54.2 D<sub>0</sub> = 5.006  
Mk 18-0 No. 16078  
ESR = 271.7 D<sub>0</sub> = 5.011

Projectile: Mk 41-0 (60.00 lb.) Empty

Cartridge Case: Mk 7

Primer: Mk 45 (XC-M5B)

Lead Foil: None

Powder: As indicated

Plug: Cork

Crimp: Cone on 2/2/53 - None on rest

Wad and Spacer: Cardboard, NGF Dwg. No. 132664  
Pc. Nos. 18 and 15 (as required)

Powder Temp.: 90°F

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Ballistic Test of Cool Propellants EX-7016 - EX-7021 inclusive, EX-7038, and EX-7048 - EX-7050 inclusive

TABULATION OF FIRING DATA (Continued)

Date: 13 December 1952

Gun: Mk 18-O, No. 16076  
ESR = 42.4 D<sub>0</sub> = 5.010

Rd. No.	Powder	PPD (in.)	Charge (lbs.)	Velocity (f/s)	Pressure (t.s.i.)	Ejec. Time (sec.)	Flash (%)	Smoke (%)
1 - 6	(Reported separately)							
(a) 7	EX-6883	4.6	20.15	2977	20.4	0.022	Tr	150
8	"	"	"	2970	20.3	0.019	75	125
9	"	"	"	2970	20.0	0.022	0	150
10	"	"	"	2972	19.9	0.021	0	150
11	"	"	"	2976	20.0	0.019	75	125
12	"	"	"	2967	19.9	0.022	0	150
Mean of 5 rounds			20.15	2971±2	20.0±0.1	0.021±0.001		
13	EX-7016	9.1	17.00	2694	18.3	0.017	0	150
14	"	6.0	18.50	2850	21.2	0.018	0	150
15	"	"	"	2850	21.8	0.017	0	150
Mean of 2 rounds			18.50	2850±0	21.5±0.3	0.018±0.001		
16	EX-7016	3.8	20.00	2990	25.9	0.017	0	150
17	EX-7017	5.1	18.50	2693	14.4	0.019	75	125
18	"	"	"	2685	14.1	0.019	75	125
Mean of 2 rounds			18.50	2689±4	14.3±0.2	0.019±0.000		
19	EX-7017	2.2	20.50	2879	17.2	0.021	75	125
20	"	1.4	21.10	2953	18.3	0.017	75	125
21	"	"	"	2954	18.2	0.019	75	125
22	"	"	"	2956	18.7	0.020	75	125
Mean of 3 rounds			21.10	2954±1	18.4±0.2	0.019±0.001		
23	EX-7018	3.1	20.00	2845	13.1	0.022	75	125
24	"	"	"	2629	12.6	0.021	75	125
Mean of 2 rounds			20.00	2637±8	12.9±0.3	0.022±0.001		

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Ballistic Test of Cool Propellants EX-7016 - EX-7021 inclusive, EX-7038, and EX-7048 - EX-7050 inclusive

TABULATION OF FIRING DATA (Continued)

Date: 13 December 1962 (Continued)

Rd. No.	Powder	PPD (in.)	Charge (lbs.)	Velocity (f/s)	Pressure (t.s.i.)	Ejec. Time (sec.)	Flash (%)	Smoke (%)
25	EX-7018	1.4	21.20	2749	14.6	0.020	100	100
26	EX-7019	8.1	17.00	2777	20.7	0.020	75	125
27	"	5.9	18.50	2927	27.0	0.016	0	150
28	"	"	"	2932	26.2	0.017	75	125
	Mean of 2 rounds		18.50	2930±3	26.6±0.4	0.017±0.001		
29	EX-7019	4.5	19.50	3036	-	0.016	75	125
30	EX-7020	6.4	17.50	2644	13.9	0.020	0	150
31	"	4.9	18.50	2753	15.6	0.021	100	100
32	"	"	"	2761	15.9	0.018	100	100
	Mean of 2 rounds		18.50	2757±4	15.8±0.2	0.020±0.002		
33	EX-7020	1.4	20.90	2998	20.3	0.016	100	100
34	"	"	"	3009	20.1	0.017	100	100
	Mean of 2 rounds		20.90	3004±6	20.2±0.1	0.017±0.001		
35	EX-7021	4.6	19.00	2588	12.5	0.019	100	100
36	"	"	"	2570	12.3	0.019	100	100
	Mean of 2 rounds		19.00	2579±9	12.4±0.1	0.019±0.000		
37	EX-7021	1.4	21.20	2813	15.3	0.020	100	100
38	"	"	"	2805	15.1	0.021	100	100
	Mean of 2 rounds		21.20	2809±4	15.2±0.1	0.021±0.001		

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Ballistic Test of Cool Propellants EX-7016 - EX-7021 inclusive, EX-7038, and EX-7048 - EX-7050 inclusive

## TABULATION OF FIRING DATA (Continued)

Date: 13 December 1952 (Continued)

Rd. No.	Powder	PPD (in.)	Charge (lbs.)	Velocity (f/s)	Pressure (t.s.i.)	Ejec. Time (sec.)	Flash (%)	Smoke (%)
39	EX-7020	5.7	16.00	2730	15.7	0.020	100	100
40	EX-7019	4.2	2.00	2844	18.5	0.017	100	100
41	"	2.7	16.00	2945	19.6	0.019	100	100
42	"	1.4	4.00	3059	23.0	0.017	100	100
43	EX-7038	8.6	17.00	2555	12.6	0.019	100	100
44	"	7.2	18.00	2656	14.1	0.021	100	100
45	"	"	"	2661	14.3	0.019	100	100
46	"	"	"	2661	14.1	0.022	100	100
Mean of 3 rounds			18.00	2659±2	14.2±0.1	0.021±0.001		
47	EX-7038	4.4	20.00	2841	16.2	0.021	100	100
48	"	1.4	22.20	3065	20.9	0.019	100	100
49	"	"	"	3071	20.3	0.017	100	100
50	"	"	"	3075	20.9	0.017	100	100
Mean of 3 rounds			22.20	3070±4	20.7±0.3	0.018±0.001		
51	EX-7048	10.9	16.00	2644	-	0.016	0	150
52	"	9.5	17.00	2747	-	0.015	0	150
53	"	15.4	13.00	2324	17.3	0.018	0	150
54	"	13.7	14.00	2429	19.9	0.017	0	150
55	"	12.3	15.00	2549	-	0.020	0	150
56	EX-7049	12.7	15.00	2361	14.0	0.018	75	125
57	"	11.4	16.00	2474	17.5	0.021	75	125
58	"	10.0	17.00	2570	20.9	0.021	75	125
59	"	9.3	17.50	2624	22.9	0.018	75	125
60	EX-7050	11.3	16.00	2387	14.0	0.018	75	125
61	"	10.0	17.00	2494	16.8	0.018	0	150
62	"	8.6	18.00	2588	18.8	0.016	100	100
63	"	6.7	19.50	2736	23.2	0.016	100	100

(a) Conditioning round.

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Ballistic Test of Cool Propellants EX-7016 - EX-7021 inclusive, EX-7038, and EX-7048 - EX-7050 inclusive

## TABULATION OF FIRING DATA (Continued)

Date: 19 December 1952

Gun: Mk 16-O, No. 14763  
ESR = 180.5 D<sub>0</sub> = 5"056

Rd. No.	Powder	PPD (in.)	Charge (lbs.)	Velocity (f/s)	Pressure (t.s.i.)	Ejec. Time (sec.)	Flash (%)	Smoke (%)
1 - 6	(Reported separately)	4.6	20.15	3007	21.4	0.019	0	150
(a) 7	EX-6883	"	"	2983	20.6	0.019	0	150
8	"	"	"	2994	21.7	-	0	150
9	"	"	"	2990	20.5	0.019	0	150
10	"	"	"	3004	21.5	0.018	0	150
11	"	"	"	2979	20.4	0.019	0	150
12	"	"	"	2990±7	20.9±0.5	0.019±0.000	0	150
Mean of 5 rounds			20.15					
13	EX-7020	4.9	18.50	2776	16.7	0.017	100	100
14	"	"	"	2774	16.4	0.018	0	150
15	"	"	"	2764	16.1	0.020	0	150
Mean of 3 rounds			18.50	2771±5	16.4±0.2	0.018±0.001		
16	EX-7020	1.6	20.75	3001	20.7	0.019	100	100
17	"	"	"	2993	20.7	0.016	100	100
18	"	"	"	3002	21.2	0.017	100	100
19	"	"	"	3005	21.1	0.017	100	100
20	"	"	"	3004	21.1	0.018	100	100
Mean of 5 rounds			20.75	3001±3	21.0±0.2	0.017±0.001		
21	EX-7020	1.4	20.90	3010	20.8	0.016	100	100
22	EX-7038	7.2	18.00	2674	14.2	0.022	0	150
23	"	"	"	2672	14.5	0.020	25	125
24	"	"	"	2675	14.4	0.021	0	150
Mean of 3 rounds			18.00	2674±1	14.4±0.1	0.021±0.001		
25	EX-7038	2.3	21.50	2977	19.3	0.020	100	100
26	"	1.4	22.20	3070	21.1	0.018	100	100
27	"	"	"	3049	20.7	0.019	100	100
28	"	"	"	3062	21.1	0.017	100	100
29	"	"	"	3059	21.1	0.017	100	100
30	"	"	"	3057	20.3	0.018	100	100
Mean of 5 rounds			22.20	3059±5	20.9±0.3	0.018±0.001		

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Ballistic Test of Cool Propellants EX-7016 - EX-7021 inclusive, EX-7038, and EX-7048 - EX-7050 inclusive

TABULATION OF FIRING DATA (Continued)

Date: 19 December 1952 (Continued)

Rd. No.	Powder	PPD (in.)	Charge (lbs.)	Velocity (f/s)	Pressure (t.s.i.)	Ejec. Time (sec.)	Flash (%)	Smoke (%)
31	EX-7020	2.0	16.00	2998	22.0	0.017	100	100
32	EX-7019	"	4.50					
33	"	"	"	3012	22.1	0.016	100	100
34	"	"	"	2998	22.0	0.016	100	100
35	"	"	"	3011	21.0	0.016	100	100
	"	"	"	3017	22.0	0.017	100	100
	Mean of 5 rounds		16.00	3007±7	21.8±0.3	0.016±0.000		
			4.50					
36	EX-7020	1.4	16.39	3049	23.5	0.016	100	100
37	EX-7019		4.61					
	"	5.7	14.05	2759	16.6	0.018	0	150
	"	"	3.95					
38	"	"	"	2762	16.8	0.016	0	150
39	"	"	"	2757	17.0	0.020	0	150
	Mean of 3 rounds		14.05	2759±2	16.8±0.1	0.018±0.001		
			3.95					
40	EX-7020 (b)	2.6	20.75	2978	22.5	0.019	100	100
41	"	2.0	21.50	3065	25.0	0.016	100	100
42	"	3.1	20.75	2983	21.0	0.016	100	100
43	"	"	"	2982	21.4	0.018	100	100
44	"	"	"	2972	21.2	0.016	100	100
	Mean of 3 rounds		20.75	2979±5	21.2±0.1	0.017±0.001		

(a) Conditioning round  
(b) Graphited

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Ballistic Test of Cool Propellants EX-7016 - EX-7021 inclusive, EX-7038, and EX-7048 - EX-7050 inclusive

TABULATION OF FIRING DATA (Continued)

Date: 19 December 1952

Gun: Mk 16-0, No. 14758  
ESR = 296.8 D<sub>0</sub> = 5.074

Rd. No.	Powder	PPD (in.)	Charge (lbs.)	Velocity (f/s)	Pressure (t.s.i.)	Ejec. Time (sec.)	Flash (%)	Smoke (%)
(a) 1	EX-6883	6.9	18.50	2730	16.4	--	0	175
2	"	4.6	20.15	2940	18.8	0.020	75	125
3	"	"	"	2941	18.5	0.018	Tr	150
4	"	"	"	2940	18.4	0.021	Tr	150
Mean of 3 rounds								
5	EX-7020	1.6	20.75	2955	19.9	0.019	100	100
6	"	"	"	2958	19.6	0.016	100	100
7	"	"	"	2962	19.4	0.018	100	100
Mean of 3 rounds								
8	EX-7038	2.3	21.50	2949	18.7	0.018	100	100
9	"	"	"	2968	18.3	0.017	100	100
10	"	"	"	2963	18.7	0.017	100	100
Mean of 3 rounds								
11	EX-7020	2.0	16.00	2975	21.4	0.017	100	100
12	EX-7019 (b)	"	4.50	2981	22.0	0.016	100	100
13	"	"	"	2968	21.4	--	100	100
Mean of 3 rounds								
14	EX-7050	7.8	18.65	2642	21.1	0.016	80	125
15	"	"	"	2645	21.8	0.019	80	125
16	"	"	"	2644	21.2	0.016	80	125
Mean of 3 rounds								
17	EX-7020 (c)	3.1	20.75	2963	20.7	0.016	100	100
18	"	"	"	2957	20.8	0.017	100	100
19	"	"	"	2956	22.3	0.017	100	100
Mean of 3 rounds								
			20.75	2959±3	21.3±0.7	0.017±0.000		

(a) Conditioning round (b) 78/22 blend (c) Graphited

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Ballistic Test of Cool Propellants EX-7016 - EX-7021 inclusive, EX-7038, and EX-7048 - EX-7050 inclusive

TABULATION OF FIRING DATA (Continued)

Date: 2 January 1953

Gun: Mk 18-O, No. 16077  
ESR = 54.2 D<sub>0</sub> = 5.006

Rd. No.	Powder	PPD (in.)	Charge (lbs.)	Velocity (f/s)	Pressure (t.s.i.)	Ejec. Time (sec.)	Flash (%)	Smoke (%)
1 - 6	(Reported separately)							
(a) 7	EX-7038	6.7	18.50	2732	15.4	0.011	50	100
8	"	"	"	2727	15.1	0.018	50	100
9	"	"	"	2723	15.1	0.019	0	150
Mean of 2 rounds			18.50	2725±2	15.1±0.0	0.019±0.001		
10	EX-7038	3.0	21.00	2971	18.3	0.018	100	100
11	"	"	"	2960	18.7	0.020	100	100
12	"	"	"	2968	18.8	0.018	100	100
13	"	"	"	2965	18.2	0.017	100	100
Mean of 4 rounds			21.00	2966±4	18.5±0.3	0.018±0.001		
14	EX-7038 (b)	3.0	21.00	2971	18.8	0.018	100	100
15	"	"	"	2949	17.4	0.018	0	150
16	"	"	"	2967	17.7	0.021	0	150
17	"	"	"	2967	17.9	0.019	100	100
18	"	"	"	2947	18.0	0.022	100	100
Mean of 5 rounds			21.00	2960±10	17.8±0.4	0.020±0.002		
19	EX-6822	7.3	18.50	2829	18.0	0.019	0	150
20	"	"	"	2817	17.5	0.022	25	100
21	"	"	"	2821	16.9	0.025	25	100
Mean of 3 rounds			18.50	2822±4	17.5±0.4	0.022±0.002		
22	EX-6822	5.0	20.20	2981	19.8	0.018	0	150
23	"	3.9	21.00	3056	21.9	0.017	0	150
24	"	3.5	21.30	3082	22.3	0.021	Tr	150
25	"	"	"	3080	21.6	0.018	Tr	150
26	"	"	"	3071	21.7	0.018	Tr	150
27	"	"	"	3069	22.2	0.017	Tr	150
28	"	"	"	3079	22.0	0.019	Tr	150
Mean of 5 rounds			21.30	3076±5	22.0±0.2	0.019±0.001		

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Ballistic Test of Cool Propellants EX-7016 - EX-7021 inclusive, EX-7038, and EX-7048 - EX-7050 inclusive

TABULATION OF FIRING DATA (Continued)

Date: 2 January 1953 (Continued)

Rd. No.	Powder	PPD (in.)	Charge (lbs.)	Velocity (f/s)	Pressure (t.s.i.)	Ejec. Time (sec.)	Flash (%)	Smoke (%)
29	EX-6822 (b)	3.5	21.30	3084	22.5	0.020	Tr	150
30	"	"	"	3064	21.7	0.021	Tr	150
31	"	"	"	3071	21.6	0.018	Tr	150
32	"	"	"	3081	21.6	0.021	100	100
33	"	"	"	3080	21.4	0.017	100	100
Mean of 5 rounds			21.30	3076±7	21.8±0.3	0.019±0.002		
34	EX-6822	3.2	21.50	3099	23.6	0.018	Tr	150
35	EX-6883	6.9	18.50	2833	17.3	0.020	0	150
36	"	"	"	2818	16.9	0.019	50	100
37	"	"	"	2828	17.5	0.020	0	150
Mean of 3 rounds			18.50	2826±6	17.2±0.2	0.020±0.000		
38	EX-6883	4.7	20.15	2982	20.2	0.019	100	100
39	"	3.4	21.00	3062	21.1	0.021	100	100
40	"	3.0	21.30	3101	21.3	0.021	Tr	150
41	"	"	"	3096	21.1	0.018	100	100
42	"	"	"	3105	21.9	0.018	Tr	150
43	"	"	"	3094	22.6	0.021	Tr	150
44	"	"	"	3099	21.4	0.018	100	100
Mean of 5 rounds			21.30	3099±3	21.7±0.5	0.019±0.001		
45	EX-6883 (b)	3.0	21.30	3102	22.1	0.021	Tr	150
46	"	"	"	3104	21.7	0.018	100	100
47	"	"	"	3101	21.8	0.018	Tr	150
48	"	"	"	3098	22.5	0.019	100	100
49	"	"	"	3103	21.3	0.018	100	100
Mean of 5 rounds			21.30	3102±0.3	21.9±0.3	0.019±0.001		
50	EX-6883	6.9	18.50	2830	17.2	0.019	100	100

(a) Conditioning round  
(b) Ex-23-1 projectile

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Ballistic Test of Cool Propellants EX-7016 - EX-7021 inclusive, EX-7038, and EX-7048 - EX-7050 inclusive

TABULATION OF FIRING DATA (Continued)

Date: 22 January 1953

Gun: Mk 16-O, No. 14763  
ESR = 180.5 D<sub>0</sub> = 5.056

Rd. No.	Powder	P.D (in.)	Charge (lbs.)	Velocity (f/s)	Pressure (t.s.i.)	Ejec. Time (sec.)	Flash (%)	Smoke (%)
(a) 1	EX-7019 (d)	8.1	17.00	2705	21.0	0.017	0	200
2	"	"	"	2779	23.9	0.018	0	150
3	"	"	"	2784	24.2	0.019	0	150
Mean of 2 rounds			17.00	2782±3	24.1±0.2	0.019±0.001		
4	EX-7019 (e)	8.1	17.00	2780	22.5	0.019	0	150
5	"	"	"	2783	23.2	0.018	0	150
Mean of 2 rounds			17.00	2782±2	22.8±0.5	0.019±0.001		
6	EX-7019 (f)	8.1	17.00	2765	20.5	0.018	0	150
7	"	"	"	2767	20.4	0.021	0	150
Mean of 2 rounds			17.00	2766±1	20.5±0.1	0.020±0.002		
8	EX-7017 (d)	1.4	21.10	2945	18.9	0.019	100	100
9	"	"	"	2951	19.1	0.018	100	100
Mean of 2 rounds			21.10	2948±3	19.0±0.1	0.019±0.001		
10	EX-7017 (e)	1.4	21.10	2929	17.8	0.018	100	100
11	"	"	"	2927	17.8	0.019	100	100
Mean of 2 rounds			21.10	2928±1	17.8±0.0	0.019±0.001		
12	EX-7017 (f)	1.4	21.10	2915	17.0	0.019	100	100
13	"	"	"	2914	17.2	0.019	100	100
Mean of 2 rounds			21.10	2915±1	17.1±0.1	0.019±0.000		

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Ballistic Test of Cool Propellants EX-7016 - EX-7021 inclusive, EX-7038, and EX-7048 - EX-7050 inclusive

TABULATION OF FIRING DATA (Continued)

Date: 22 January 1953 (Continued)

Rd. No.	Powder	PPD (in.)	Charge (lbs.)	Velocity (f/s)	Pressure (t.s.i.)	Ejec. Time (sec.)	Flash (%)	Smoke (%)
14	EX-6883 (d)	4.4	20.15	2965	19.3 (b) 19.7 (c)	0.023	100	100
15	"	"	"	2959	--	0.021	100	100
16	"	"	"	2953	20.1 (c) 19.3 (b) 19.8 (c)	0.021	100	100
17	"	"	"	2950	19.2 (b) 20.0 (c)	0.021	100	100
18	"	"	"	2957	19.1 (b) 20.8 (c)	0.020	100	100
Mean of 5 rounds			20.15	2957±4	19.2±0.1 (b) 20.0±0.3 (c)	0.021±0.001		
19	EX-6883 (e)	4.4	20.15	2947	19.7	0.022	100	100
20	"	"	"	2951	20.0	0.023	0	150
Mean of 2 rounds			20.15	2949±2	19.9±0.2	0.023±0.001		
21	EX-6883 (f)	4.4	20.15	2939	19.4	--	100	100
22	"	"	"	2976	21.8	--	100	100
Mean of 2 rounds			20.15	2958±19	20.6±1.2			
23	EX-7017	5.1	18.50	2664	13.7	0.019	100	100

- (a) Conditioning round  
 (b) T-1070 - Static calibration pressure for 1/6 sq. in. area gauges  
 (c) MI-2 - Dynamic calibration pressure for 1/6 sq. in. area gauges  
 (d) 800 grams of black powder in primer  
 (e) 600 " " " " " "  
 (f) 400 " " " " " "

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Ballistic Test of Cool Propellants EX-7016 - EX-7021 inclusive, EX-7038, and EX-7048 - EX-7050 inclusive

TABULATION OF FIRING DATA (Continued)

Date: 27 January 1953

Gun: Mk 16-0, No. 14763  
ESR = 180.5 D<sub>0</sub> = 5.056

Ed. No.	Powder	PPD (in.)	Charge (lbs.)	Velocity (f/s)	Pressure			Ejec. Time (sec.)	Flash (%)	Smoke (%)
					(t.s.i.)(b)	(t.s.i.)(c)	(t.s.i.)(d)			
(a) 1	EX-7019	7.7	17.00	2761	19.5	19.4	20.0	0.020	0	100
2	EX-6822	3.0	21.56	3084	22.3	22.4	22.4	0.018		
3	"	"	"	3056	20.7	22.1	22.0	0.022		
	Mean of 2 rounds		21.56	3070±15	21.5±0.8	22.3±0.2	22.2±0.2	0.020±0.002		
4	EX-7019	7.7	17.00	2763	20.9	21.0	20.6	0.019		
5	"	"	"	2773	21.7	21.3	20.5	0.016		
6	"	"	"	2763	20.4	20.2	20.7	0.022		
	Mean of 3 rounds		17.00	2766±4	21.0±0.5	20.8±0.4	20.6±0.1	0.019±0.002		

- (a) Conditioning round  
 (b) T-1070 - Static calibration pressure for 1/6 sq. in. area gauges  
 (c) MI-2 - Dynamic calibration pressure for 1/6 sq. in. area gauges  
 (d) MI-3 - Dynamic calibration pressure for 1/30 sq. in. area gauges

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Ballistic Test of Cool Propellants EX-7016 - EX-7021 inclusive, EX-7038, and EX-7048 - EX-7050 inclusive

TABULATION OF FIRING DATA (Continued)

Date: 28 January 1953

Gun: Mk 16-0, No. 14763  
ESR = 180.5 D<sub>0</sub> = 5.056

Rd. No.	Powder	PPD (in.)	Charge (lbs.)	Velocity/ (f/s)	Pressure			Ejec. Time (sec.)	Flash (%)	Smoke (%)
					(t.s.i.)(b)	(t.s.i.)(c)	(t.s.i.)(d)			
(a) 1	EX-7019	7.7	17.00	2769	20.6	21.2	20.6	-	-	-
2	EX-6883	2.6	21.28	3052	20.5	21.2	21.5	-	-	-
3	"	"	"	3055	21.1	21.9	22.2	-	-	-
4	"	"	"	3071	21.6	21.2	22.7	0.021	-	-
5	"	"	"	3068	22.2	22.3	21.7	0.017	-	-
6	"	"	"	3070	22.7	22.0	23.0	0.021	-	-
Mean of 5 rounds					21.6±0.7	21.7±0.4	22.2±0.5	0.020±0.002(e)	-	-

- (a) Conditioning round  
(b) T-1070 - Static calibration pressure for 1/6 sq. in. area gauges  
(c) MI-2 - Dynamic calibration pressure for 1/6 sq. in. area gauges  
(d) MI-3 - Dynamic calibration pressure for 1/30 sq. in. area gauges  
(e) Based on 3 rounds

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Ballistic Test of Cool Propellants EX-7016 - EX-7021 inclusive, EX-7038, and EX-7048 - EX-7050 inclusive

TABULATION OF FIRING DATA (Continued)

Date: 2 February 1953

Gun: Mk 18-O, No. 16078  
ESR = 271.7 D<sub>0</sub> = 5.011

Rd. No.	Powder	PPD (in.)	Charge (lbs.)	Velocity (f/s)	Pressure (t.s.i.)	Ejec. Time (sec.)	Flash (%)	Smoke (%)
(a) 1	EX-6883	3.0	21.31	3045	23.2	0.019	0	150
2	"	"	"	3084	23.2	0.017	100	100
3	"	"	"	3072	23.0	0.020	100	100
4	"	"	"	3088	22.0	0.021	Tr	150
5	"	"	"	3086	22.7	0.021	100	100
6	"	"	"	3091	23.6	0.017	75	125
Mean of 5 rounds			21.31	3084±5	22.9±0.4	0.019±0.002		
7	EX-6822	3.2	21.56	3085	23.7	0.018	100	100
8	"	"	"	3094	23.8	0.020	100	100
9	"	"	"	3096	23.9	0.016	100	100
10	"	"	"	3100	22.4	0.016	100	100
11	"	"	"	3089	23.8	0.021	100	100
Mean of 5 rounds			21.56	3093±5	23.5±0.5	0.018±0.002		

Note: Cone crimp assembly on all rounds.

(a) Conditioning round.

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Ballistic Test of Coal Propellants EX-7016 - EX-7021 inclusive,  
EX-7038, and EX-7048 - EX-7050 inclusive  
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PRESSURE TIME-CURVES

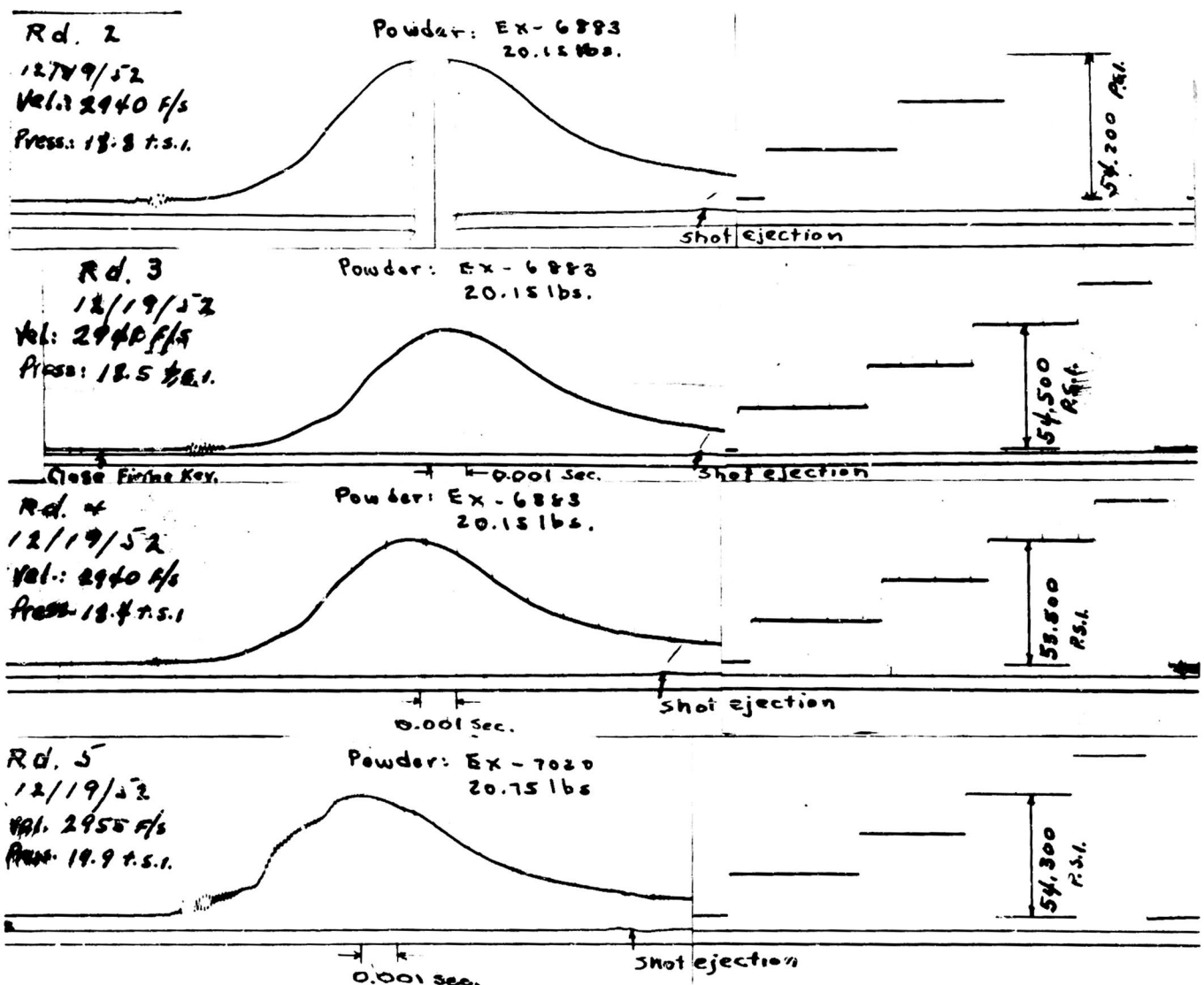
Gun: 5"/54 caliber Mk 16-0, No's. 14758 and 14763  
Projectile: Mk 41-0 (60.00 lb.) Empty  
Cartridge Case: Mk 7  
Primer: Mk 45  
Lead Foil: None  
Powder: As indicated  
Plug: Cork  
Was and Spacer: Cardboard, NGF Dwg. 132664  
Pc. Nos. 18 and 15 (as required)  
Powder Temp.: 90°F

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Ballistic Test of Cool Propellants EX-7016-EX-7021 Inclusive,  
EX-7038, and EX-7048-EX-7050 Inclusive

PRESSURE-TIME CURVES



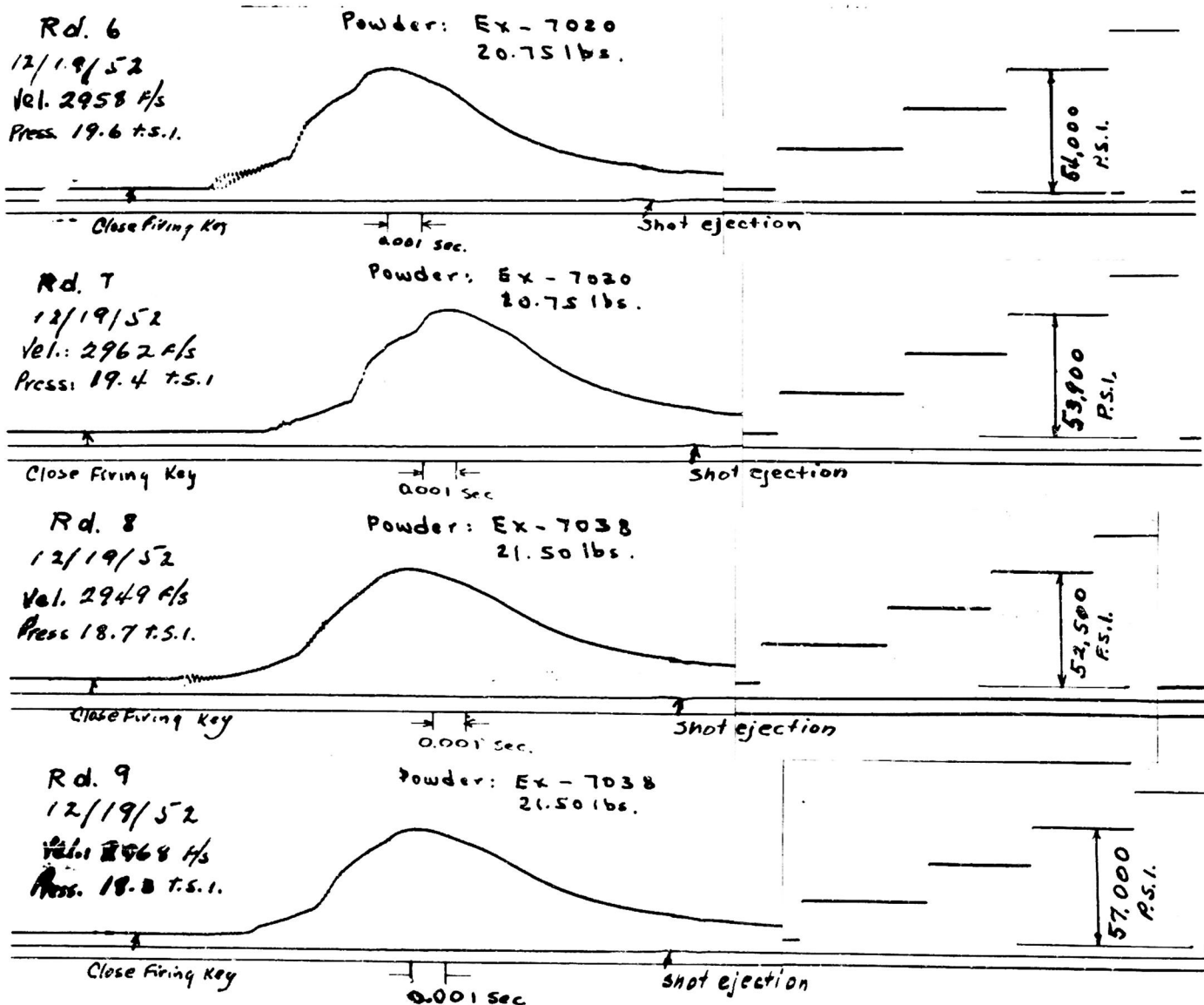
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Ballistic Test of Cool Propellants EX-7016-EX-7021 Inclusive,  
EX-7038, and EX-7048-EX-7050 Inclusive

PRESSURE-TIME CURVES



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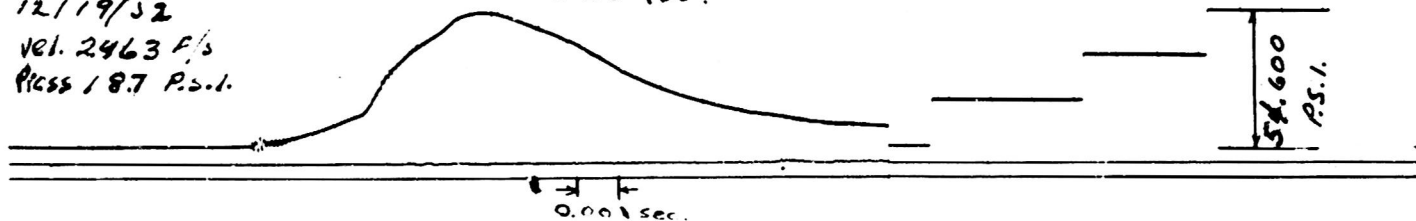
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PRESSURE-TIME CURVES

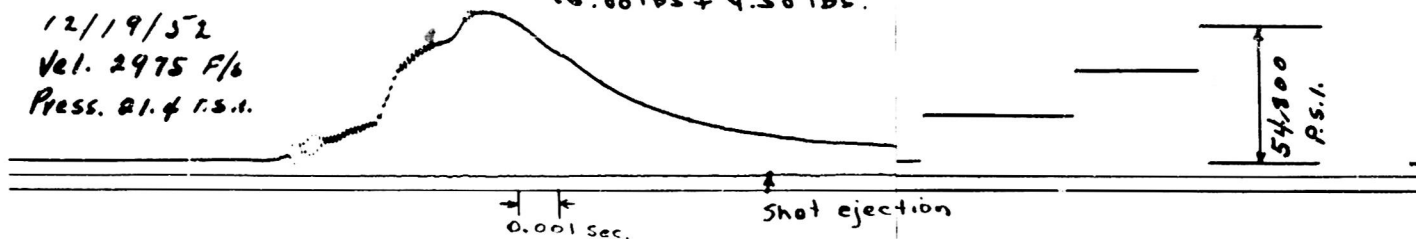
Rd. 10  
12/19/52  
Vel. 2463 F/s  
Press 18.7 P.S.I.

Powder: EX-7038  
21.50 lbs.



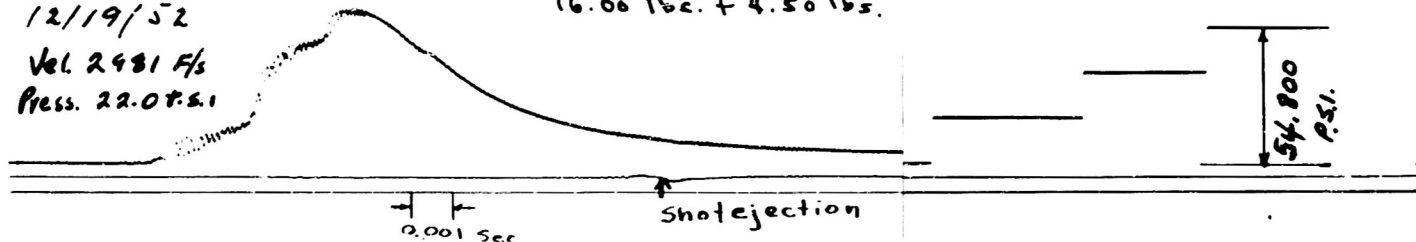
Rd. 11  
12/19/52  
Vel. 2975 F/s  
Press. 21.4 P.S.I.

Powder: EX-7020 + EX-7019  
16.00 lbs + 4.50 lbs.



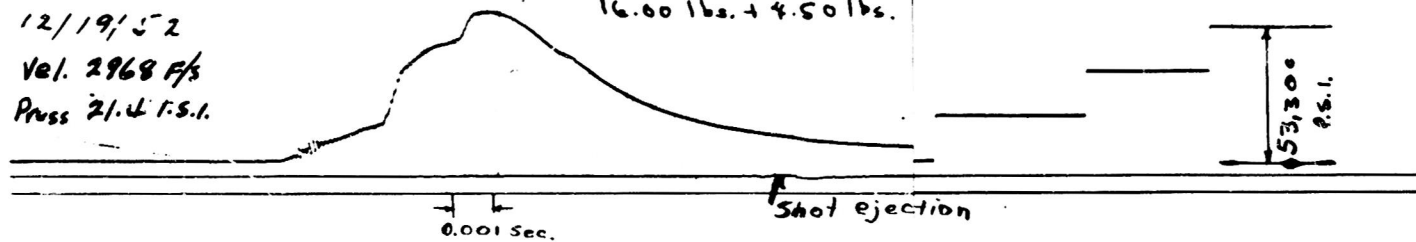
Rd. 12  
12/19/52  
Vel. 2981 F/s  
Press. 22.0 P.S.I.

Powder: EX-7020 + EX-7019  
16.00 lbs. + 4.50 lbs.



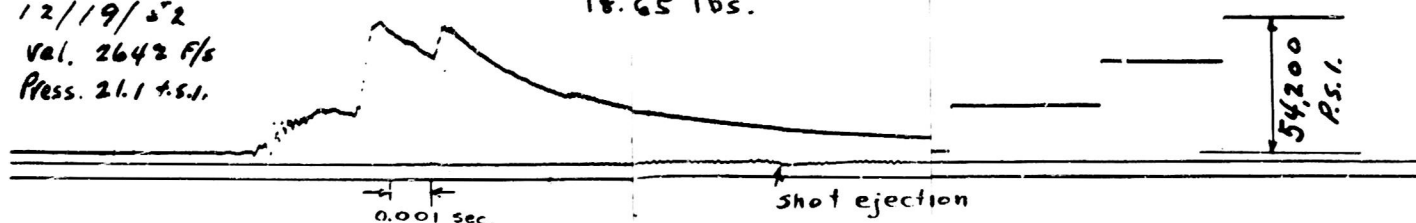
Rd. 13  
12/19/52  
Vel. 2968 F/s  
Press 21.4 P.S.I.

Powder: EX-7020 + EX-7019  
16.00 lbs. + 4.50 lbs.



Rd. 14  
12/19/52  
Vel. 2642 F/s  
Press. 21.1 P.S.I.

Powder: EX-7050  
18.65 lbs.

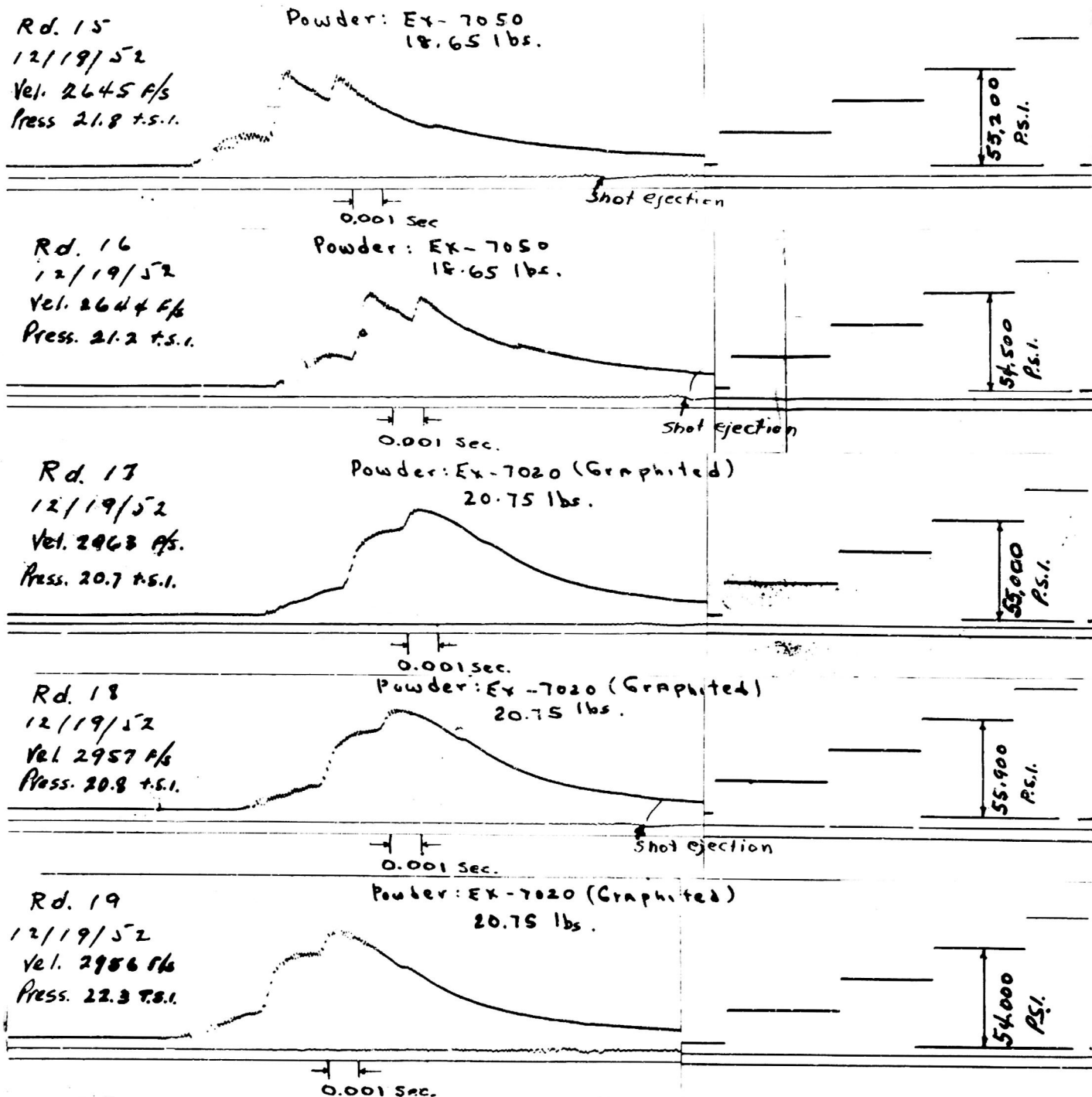


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Ballistic Test of Cool Propellants EX-7016-EX-7021 Inclusive,  
EX-7038, and EX-7048-EX-7050 Inclusive

PRESSURE-TIME CURVES



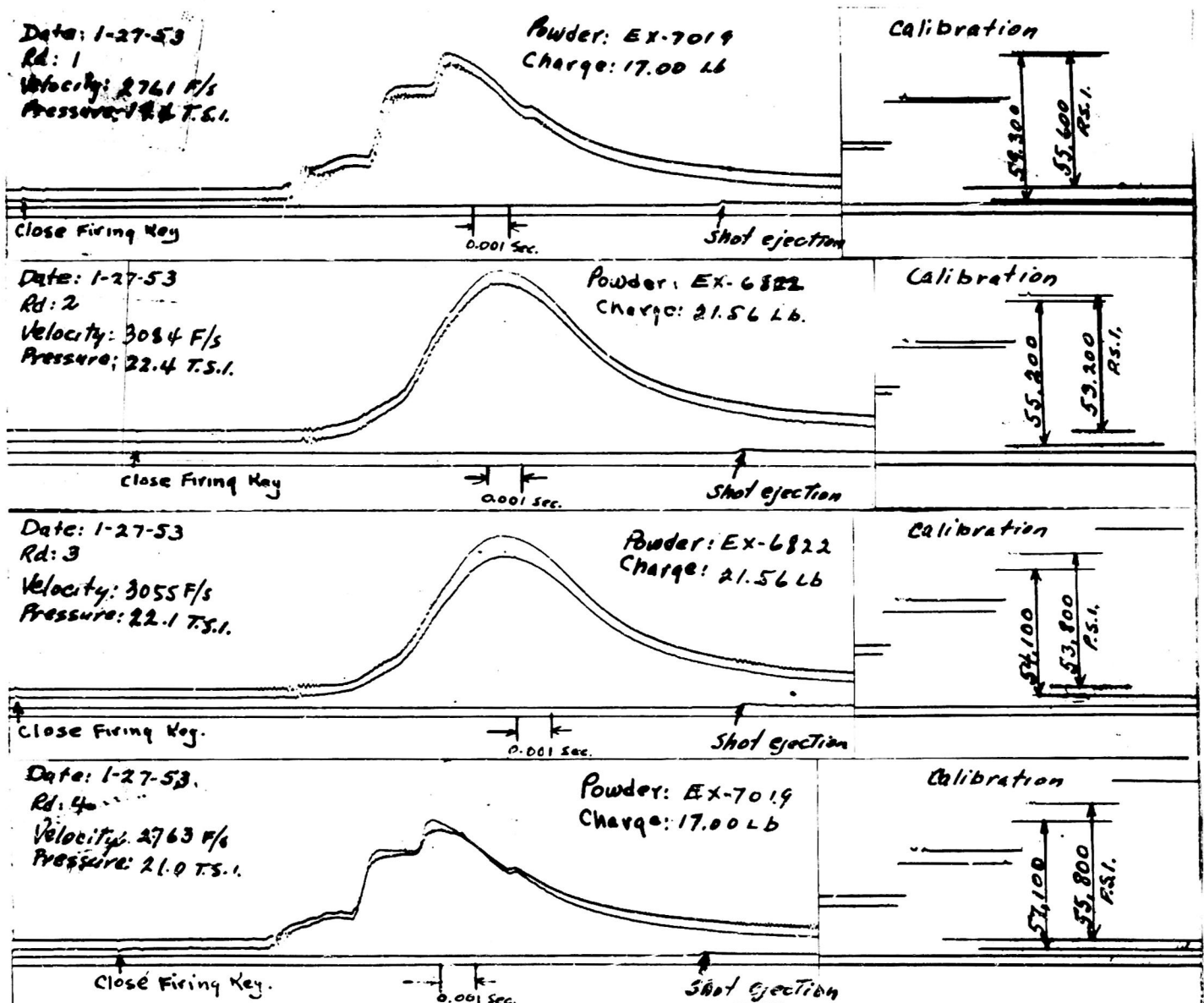
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Ballistic Test of Cool Propellants EX-7016-EX-7021 Inclusive,  
EX-7038, and EX-7048-EX-7050 Inclusive

PRESSURE-TIME CURVES

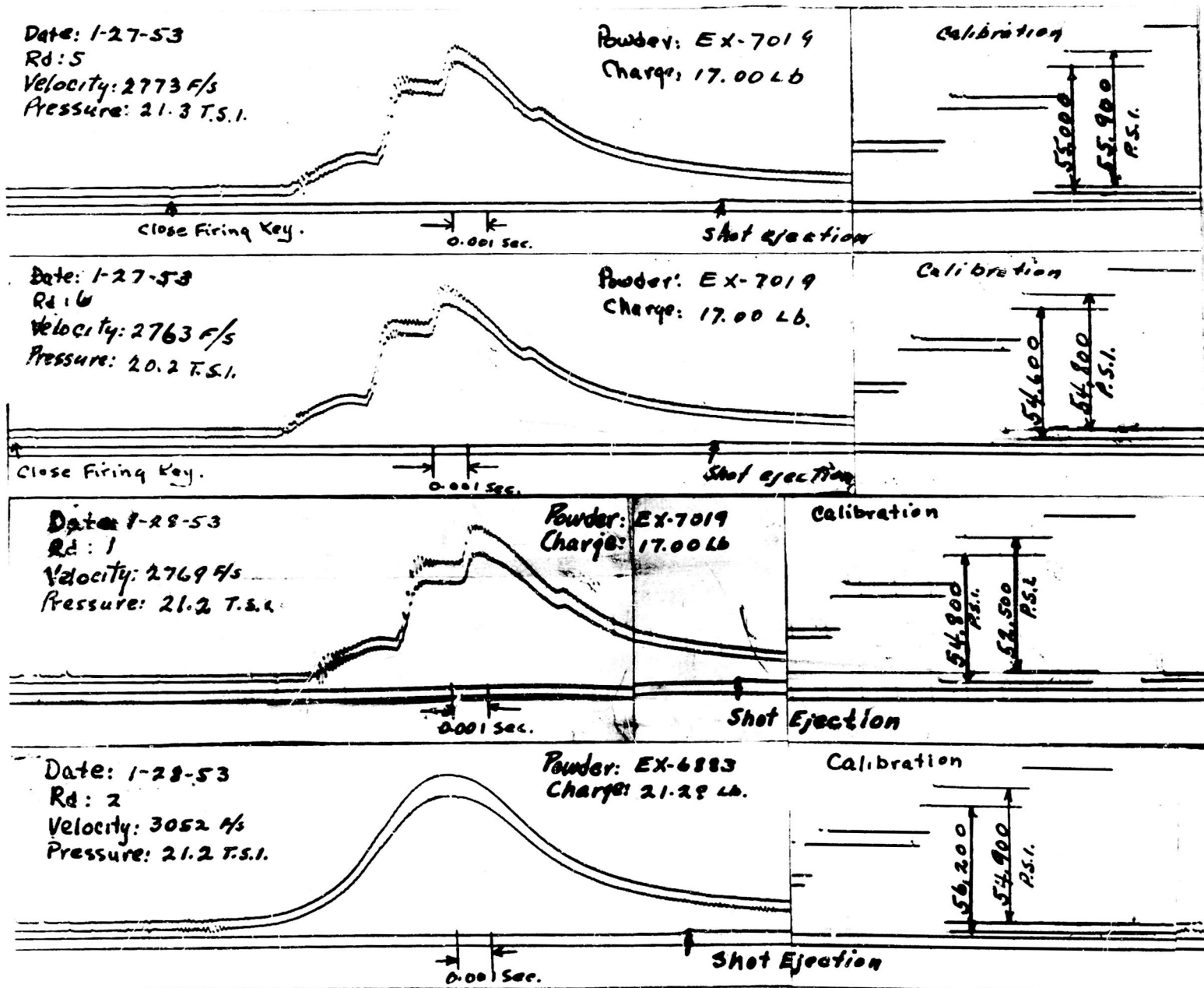


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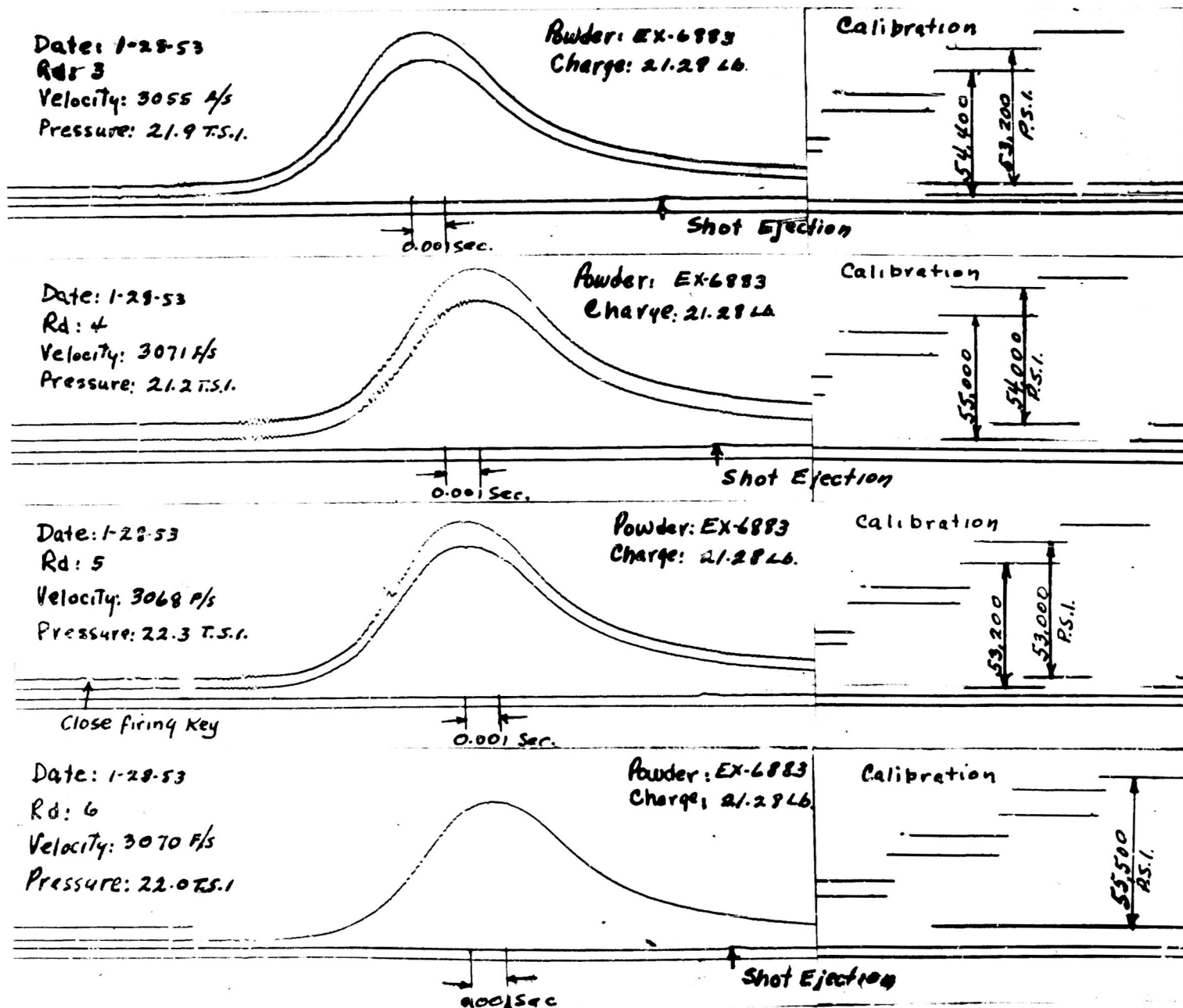
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EX-7038, and EX-7048-EX-7050 Inclusive

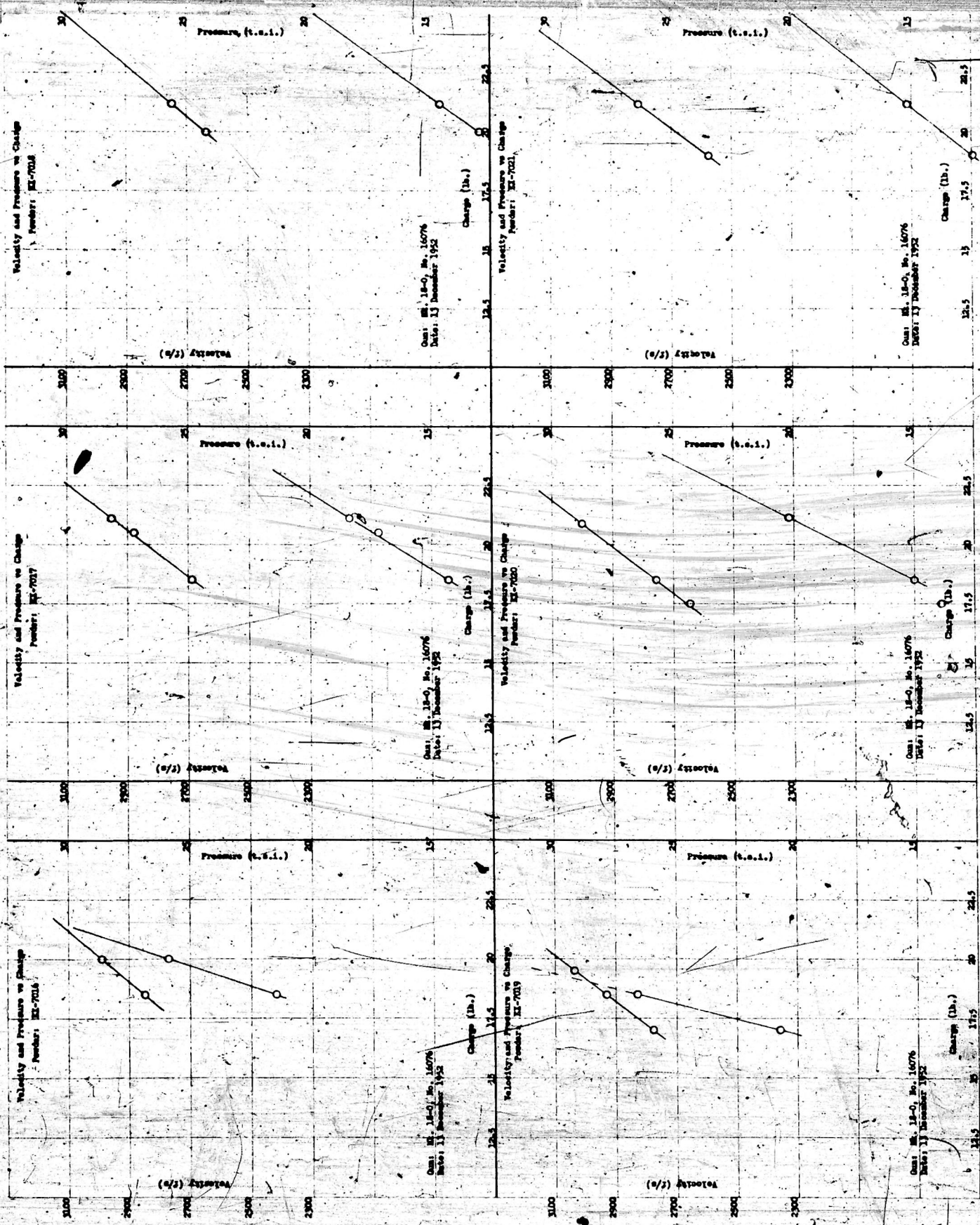
PRESSURE-TIME CURVES



Ballistic Test of Cool Propellants EX-7016-EX-7021 Inclusive,  
EX-7038, and EX-7048-EX-7050 Inclusive

PRESSURE-TIME CURVES







BALLISTIC TEST OF COOL PROPELLANTS

Velocity and Pressure vs Charge  
Powder: EL-7019

(a/s) Velocity

Pressure (t.s.i.)

Velocity and Pressure vs Charge  
Powder: EL-7019

(a/s) Velocity

Pressure (t.s.i.)

Velocity and Pressure vs Charge  
Powder: EL-7019 and  
EL-7019

(a/s) Velocity

Pressure (t.s.i.)

Gun: M. 18-O, No. 16076  
Date: 13 December 1952

Gun: M. 18-O, No. 16076  
Date: 13 December 1952

Gun: M. 18-O, No. 16076  
Date: 13 December 1952

Velocity and Pressure vs Charge  
Powder: EL-7019

(a/s) Velocity

Pressure (t.s.i.)

Velocity and Pressure vs Charge  
Powder: EL-7020

(a/s) Velocity

Pressure (t.s.i.)

Velocity and Pressure vs Charge  
Powder: EL-7020

(a/s) Velocity

Pressure (t.s.i.)

Velocity and Pressure vs Charge  
Powder: EL-7019

(a/s) Velocity

Pressure (t.s.i.)

Gun: M. 18-O, No. 16076  
Date: 13 December 1952

Gun: M. 18-O, No. 16076  
Date: 13 December 1952

Gun: M. 18-O, No. 16076  
Date: 13 December 1952

Velocity and Pressure vs Charge  
Powder: EL-7019

(a/s) Velocity

Pressure (t.s.i.)

Velocity and Pressure vs Charge  
Powder: EL-7020

(a/s) Velocity

Pressure (t.s.i.)

Velocity and Pressure vs Charge  
Powder: EL-7020

(a/s) Velocity

Pressure (t.s.i.)

Velocity and Pressure vs Charge  
Powder: EL-7019

(a/s) Velocity

Pressure (t.s.i.)

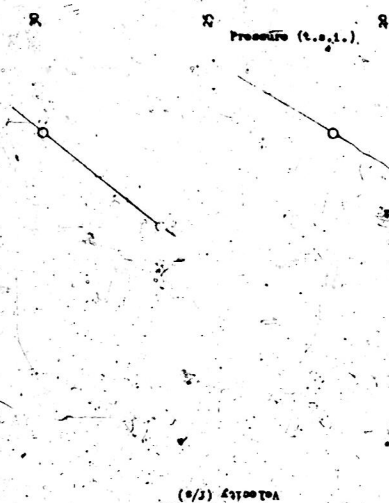
MP: 0108 No. 1150

Velocity and Pressure vs Charge  
Powder: EL-7020



Qns: M. 16-0, No. 1677  
Date: 19 December 1952

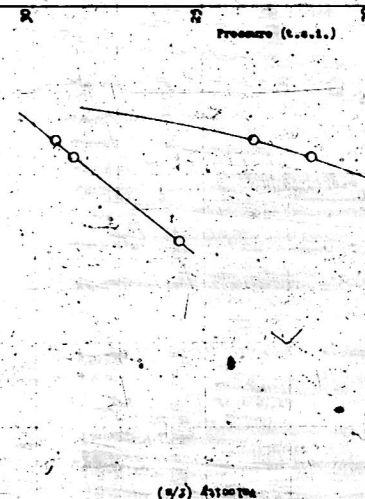
Velocity and Pressure vs Charge  
Powder: EL-685



Qns: M. 16-0, No. 1677  
Date: 2 January 1953

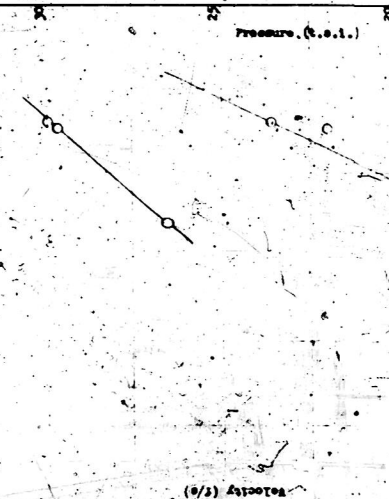
BALLISTIC TEST OF COIL PROPPELLANT

Velocity and Pressure vs Charge  
Powder: EL-7020 - 78  
Alum: EL-7019 - 12



Qns: M. 16-0, No. 1677  
Date: 19 December 1952

Velocity and Pressure vs Charge  
Powder: EL-622



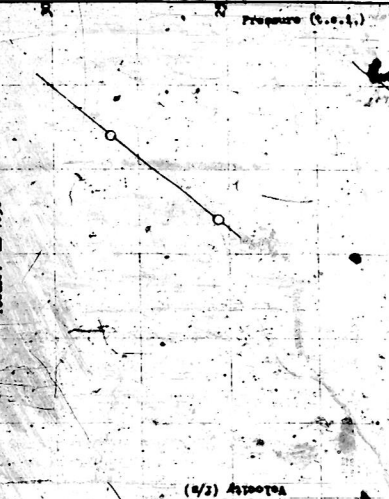
Qns: M. 16-0, No. 1677  
Date: 2 January 1953

Velocity and Pressure vs Charge  
Powder: EL-7020



Qns: M. 16-0, No. 1677  
Date: 19 December 1952

Velocity and Pressure vs Charge  
Powder: EL-7020



Qns: M. 16-0, No. 1677  
Date: 2 January 1953